What is claimed is:

[c1] A cryogen free superconducting magnet assembly comprising:

a high T_c superconducting magnet; and

a thermal reservoir in thermal contact with the high T_c superconducting magnet,

wherein the thermal reservoir comprises a material having a heat capacity of at least about 0.065 J/gK at 25 K.

[c2] The assembly of claim 1, wherein the thermal reservoir substantially surrounds the high T_c superconducting magnet.

[c3] The assembly of claim 1, wherein the thermal reservoir comprises a material having a heat capacity of at least about 0.10 J/gK at 25 K.

[c4] The assembly of claim 1, wherein the thermal reservoir comprises a material having a minimum enthalpy change of at least about 0.65 J/g between 20 K and 30 K.

[c5] The assembly of claim 4, wherein the thermal reservoir comprises a material having a minimum enthalpy change of at least about 1.55 J/g between 20 K and 30 K.

[c6] The assembly of claim 3, wherein the thermal reservoir material comprises ice, epoxy, methacrylate, polyurethane, synthetic rubber, natural rubber, plastic, resin, or lead.

[c7] The assembly of claim 1, further comprising a cryocooler.

[c8] The assembly of claim 7, wherein the cryocooler is thermally connected to the high T_c superconducting magnet.

[c9] The assembly of claim 8, further comprising a high thermal conductivity connector connecting the cryocooler to the high T_c superconducting magnet.

[c10] The assembly of claim 9, wherein the connector comprises copper.

[c11] The assembly of claim 9, wherein the connector comprises a heat pipe.

[c12] The assembly of claim 1, wherein the reservoir has a thermal capacity greater than about 9×10^5 J.

[c13] The assembly of claim 1, wherein the critical temperature of the high T_c superconducting magnet is greater than 20 K.

[c14] The assembly of claim 1, wherein the reservoir has a thermal mass greater than about 525 kg.

[c15] The assembly of claim 1, wherein the thermal reservoir has sufficient mass to provide ride-through of at least 5 hours.

[c16] The assembly of claim 15, wherein the thermal reservoir has sufficient mass to provide ride-through of at least 10 hours.

[c17] An MRI system comprising:

a superconducting magnet assembly of claim 1,

wherein an imaging volume is formed inside the superconducting magnet assembly.

[c18] A magnetic separator comprising at least one superconducting magnet assembly of claim 1.

[c19] A superconducting motor or generator comprising at least one superconducting magnet assembly of claim 1.

[c20] A method of cooling a cryogen free superconducting magnet assembly comprising:

providing a high T_c superconducting magnet thermally connected to a thermal reservoir, the thermal reservoir comprising a material having a heat capacity of at least about 0.065 J/gK at 25 K;

providing a cryocooler thermally connected to the high T_c superconducting magnet; and

withdrawing heat from the high T_c superconducting magnet without using a cryogen.

[c21] The method of claim 20, wherein the thermal reservoir substantially surrounds the high T_c superconducting magnet.

[c22] The method of claim 20, further comprising maintaining a temperature of the high T_c superconducting magnet above approximately 20 K.

[c23] The method of claim 22, further comprising maintaining the high T_c superconducting magnet below the critical temperature for at least about 5 hours after a cryocooler shut down.

[c24] The method of claim 23, further comprising maintaining the high T_c superconducting magnet below the critical temperature for at least about 10 hours after a cryocooler shut down.

[c25] The method of claim 20, wherein the thermal reservoir comprises a material having a minimum enthalpy change of at least about 0.65 J/g between 20 K and 30 K.

[c26] The method of claim 25, wherein the reservoir material comprises ice, epoxy, methacrylate, polyurethane, synthetic rubber, natural rubber, plastic, resin, or lead.

[c27] The method of claim 20, wherein a cryocooler is thermally connected to the high T_c superconducting magnet.

[c28] An MRI system comprising:

a cryogen free superconducting magnet assembly having a high T_c superconducting magnet, and a thermal reservoir in thermal contact with the high T_c superconducting magnet, the thermal reservoir comprising a material having a heat capacity of at least about 0.065 J/gK at 25 K, wherein an imaging volume is formed inside the superconducting magnet assembly; and

a cryocooler thermally connected to the thermal reservoir.

[c29] The MRI system of claim 28, wherein the thermal reservoir substantially surrounds high T_c superconducting magnet.

[c30] The MRI system of claim 28, further comprising gradient coils located between the cryogen free superconducting magnet assembly and the imaging volume.

[c31] The MRI system of claim 30, further comprising a passive iron shield surrounding the high T_c superconducting magnet.

[c32] The MRI system of claim 31, wherein the thermal reservoir is located between the gradient coils and the passive iron shield.

[c33] The MRI system of claim 31, wherein the thermal reservoir is located outside the passive iron shield.

[c34] The MRI system of claim 32, wherein the thermal reservoir is enclosed in a vacuum chamber.

[c35] An MRI system comprising:

a first cryogen free superconducting magnet assembly having a first high T_c superconducting magnet, and a first thermal reservoir in thermal contact with the first high T_c superconducting magnet, the first thermal reservoir comprising a material having a heat capacity of at least about 0.065 J/gK at 25 K; and

a second cryogen free superconducting magnet assembly having a second high T_c superconducting magnet, and a second thermal reservoir in thermal contact with the second high T_c superconducting magnet, the second thermal reservoir comprising a material having a heat capacity of at least about 0.065 J/gK at 25 K, wherein an imaging volume is formed between the first and second assemblies.

[c36] The MRI system of claim 35, further comprising at least one cryocooler thermally connected to the first thermal reservoir.

[c37] The MRI system of claim 36, wherein the cryocooler is thermally connected to the first thermal reservoir and the second thermal reservoir.

[c38] The MRI system of claim 36, further comprising gradient coils located between the first and second cryogen free superconducting magnet assemblies.

[c39] The MRI system of claim 38, further comprising a first passive iron shield surrounding the first high T_c superconducting magnet and a second passive iron shield surrounding the second high T_c superconducting magnet.

[c40] The MRI system of claim 39, wherein the first cryogen free superconducting magnet assembly is enclosed in a first vacuum chamber and the second cryogen free superconducting magnet assembly is enclosed in a second vacuum chamber.

[c41] An MRI system comprising:

a first cryogen free superconducting magnet assembly having a first high T_c superconducting magnet;

a second cryogen free superconducting magnet assembly having a second high T_c superconducting magnet; and

a thermal reservoir in thermal contact with the first and second high T_c superconducting magnets, the thermal reservoir comprising a material having a heat capacity of at least about 0.065 J/gK at 25 K,

wherein an imaging volume is formed between the first and second assemblies.

[c42] The MRI system of claim 41, further comprising at least one cryocooler thermally connected to the thermal reservoir.

[c43] The MRI system of claim 42, further comprising gradient coils located between the first and second cryogen free superconducting magnet assemblies.

[c44] The MRI system of claim 43, further comprising a first passive iron shield surrounding the first high T_c superconducting magnet and a second passive iron shield surrounding the second high T_c superconducting magnet.